October 22, 1969

RATIONALE FOR THE DEVELOPMENT OF THE FULL-TIME GRADUATE PROGRAMME IN STRUCTURES

Summary

In response to the question of the EGSC as to the number of D.Eng. students which should be accepted in the graduate programme in Structures at S.G.W.U., we have concluded that the estimate of the members should be in terms of full-time-equivalent students rather than in terms of D.Eng. students only.

In order to answer such a question one must consider (a) the need in society for the graduates with advanced education in Structures, (b) the growth of D.Eng. programme in Structures to date, (c) the capability of our laboratories, (d) the available faculty capability to supervise these students and (e) the financial resources available to support research.

The study shows that (i) Professional Engineers with advanced degrees in Structures are in demand, (ii) our research activities do not overlap those of other Canadian Universities, (iii) the graduate programme in structures has received recognition and support from industry, (iv) to achieve optimum use of our present and planned facilities and equipment in our laboratories, we should have approximately 30 full-time-equivalent graduate students, (v) the research potentials and activities of the present faculty members in Structures can be best realized and optimized by the supervision of 29 full-time-equivalent graduate students (fourteen of these being D.Eng. students),

(vi) available research grants could support three additional D.Eng. students, whereas the projected grants could support by 1972-73 two research associates, three Doctoral Fellowships, twelve D.Eng. students, six research assistants, and four Faculty Fellowships.

According to our projected development it would seem reasonable to admit thirty full-time-equivalent graduate students by 1972-73, half of these being Doctoral students.

Introduction

In the field of Structures, one deals mainly with conceiving and properly proportioning of structural systems such as buildings and bridges and their components (such as beam and columns) to resist the actual or probable loading and climatic conditions that may be imposed upon them. Thus, the floors of a building must be sufficiently strong for their intended purpose; the shaft of a machine must be of adequate size to carry the required torque; a wing of an airplane must safely withstand the aerodynamic loads which may come upon it in flight or landing; a suspension bridge must remain stable under severe wind conditions. In engineering practice, all the above requirements must be met with minimum expenditure of materials, manufacturing or construction cost.

The extent to which these criteria of optimum design are met depends largely on the professional qualifications of the designer. He must rely on his imagination and good judgement

for the selection of the optimum structural system for the particular application. He must have an extensive knowledge of Applied Mathematics and computational methods to resolve external forces into forces acting on the component elements of the structural system. Since the structure can be built out of different materials such as steel, aluminum and concrete, the designer must know their mechanical properties to proportion them correctly. In some cases, these materials may be used in combination in the form of composite or sandwich elements in order to achieve optimum efficiency, thus requiring the designer to be familiar with the behaviour of composite construction. Experimental stress techniques must be used when structures of irregular shape do not lend themselves to mathematical analysis.

At the undergraduate level, it is possible to teach only the basic principles of the above topics to our students in Structures. After consolidating these principles in industry the engineers may continue their professional training through our Master of Engineering Programme. In fact, thirty such engineers from industry are now enrolled in our programme. Because of its part-time nature, the M.Eng. programme provides an invaluable service to the industrial community, but does not contribute significantly to the advancement of technology. Meaningful research can be carried out only at the D.Eng. level.

Need For Research in Structures

Among the many products related to the study of Structures are buildings, building systems, towers, aircrafts, vehicles, rolling stock, structural materials, materials processing, etc.

These all contribute significantly to the growth of the Canadian economy.

Innovations in Building Technology is dictated by (a) the shortage and high cost of trained labour, (b) by the present shortage of shelter space and (c) by the heavy demand on building space created by the population explosion (see References 1 and 2). The U.S. Government has estimated a requirement of 26 million apartment units within the next decade and is urging industry to utilize Building Industrialization. Prefabricated stress-skinned panels can replace column and beam construction, thus giving rise to topics of research in panelized building systems, in stress-skinned panels themselves, and in connections of such panels.

Research interest has been developed in bridges during the past decade with the introduction of a new concept for bridge decks and new bridge systems. Development of orthotropic bridge theory and new systems found wide application all over the world and particularly in North America. However, many basic problems connected to these new systems required further investigation and research.

In the Aircraft Industry research is required to achieve designs of lighter and safer aircraft structures.

D.Eng. graduates with research background in the above three topics may thus be expected to be in high demand in the immediate future.

Research in Structures at S.G.W.U.

To date, the research activities in Structures have been concentrated on the first two topics described above - panelized building systems and bridge systems. These research activities are not overlapping any similar research activities at other Canadian Universities (see Reference 3).

MIT sponsored an international two-week conference on Industrialized Building last August. Universities such as Cornell, Washington, Montreal, Toronto have established groups to study the architectural aspects of Building Industrialization. At S.G.W.U. we have set out to study the engineering problems of these systems such as structural behaviour under normal and earthquake loads, heat effects on panels, connection of panels, creep, etc.

To make the study in Industrialized Building more effective the nucleus of a group entitled The Division of Environmental Systems has been formed within the Faculty of Engineering under the chairmanship of Professor Cedric Marsh. Its function is to draw from the various relevant departments and faculties additional members who, in addition to their present roles, would constitute an "action committee" promoting studies, seminars, papers and other publications related to the building field, with particular emphasis on building systems and the systems approach to building. D.Eng. students would be involved in the study and development of building components, analysis of building, architecture, construction and the examination of the socio-economic environment as it relates to buildings.

A two-day symposium on panelized building systems will be held at Sir George Williams University in June of 1970. The symposium is intended to bring together the Aluminum, Steel, Concrete and Wood industries from Canada and the USA in order to discuss the future potentials and problems of building systems as viewed by each of these industries. Over two hundred engineers from the Montreal community are expected to attend. The cost of the symposium is being paid by industry.

Development of D.Eng. Programme To Date

Since the approval of the D.Eng. programme in Sturctures in 1968 (see D.Eng. proposal), the following progress has been made:

I) Faculty. Two additional faculty members have joined the Structures group. Dr. P. Fang came in 1968 from U.S. Steel Corp. where he was in charge of research and development of structural systems for high rise buildings. Recently he was named to the Directory of "Engineers of Distinction". Professor C. Marsh, a well-known consulting engineer in Montreal and Adjunct Professor at the University of Waterloo before he joined us this year, advises the Aluminum Company of Canada on policies of university-sponsored research; he has an extensive background in building systems. Dr. T.S. Sankar (with his background in Applied Mechanics) and Dr. M.O.M. Osman (with his knowledge of structures for machines), both from the Mechanical Department, have also joined our group to bring its total number to eight.

II) D.Eng. Students. Three D.Eng. students have entered

our programme. Mr. B. Lazar, a senior structural engineer at Rust Engineers Consulting Co., was the first one to join us carrying with him an NRC PIER fellowship of $7,200 per annum for two years. His tuition fees are being paid by Dominion Bridge Co. Mr. Lazar has completed the course requirement and is well into his research project. He is scheduled for the general examination on October 30, in order to be admitted into the candidacy for the D.Eng. Degree. Our second student, Mr. Salahuddin was admitted in the programme in September, 1968, after having completed his Master Degree in Civil Engineering, at Columbia University. Prior to entering the Master Programme, he spent four years in industry where his work gained high esteem from his peers. Mr. Salahuddin is now being supported on a fellowship from Alcan in the amount of $4000 per annum for two years. He will have completed his course requirements by January 1970 and is scheduled for the general examination on that date. The third student, Mr. J. Mikler, has registered this fall after having completed one year of research studies in the Graduate School at the University of Waterloo. He came originally from the Institute of Construction and Architecture of the Slovak Academy of Science in Bratislava, Czechoslovakia. Mr. Mikler has an extensive background in building systems, and has been able to define his research problem in less than two months. He will carry out studies on the model of a panelized building built to half scale of the prototype and estimated at about $15,000. Most of this cost will be absorbed by industry. Mr. Mikler is being supported on a fellowship from Alcan in the amount of $5,000 per annum.

III) Financial Support. Generous grants have been awarded to members in Structures by both NRC and by industry. NRC grants increased from $20,060 in 1968 to $33,900 in 1969. Alcan increased its support from $4,00 in 1968 to $14,000 in 1969. Dominion Bridge Co. is paying the tuition fees for Mr. Lazar. Stelco has agreed to support a research project on steel structures and is at present reviewing the nature and amount of the support. The company has already donated a considerable amount of materials. No D.Eng. student can be involved in this porject because of the arbitrary restriction which limits to a total of six the number of Doctoral students permitted in the three research areas in the Faculty of Engineering. The concrete and wood industries have shown great interest in our fields of study and have asked us to submit proposals for research assistance. These proposals are being delayed since Faculty members require the competent assistance of D.Eng. students to fulfill research commitments.

IV) Courses. Advanced courses, most of which are in the fore-front of modern engineering practice, have already been established for the M.Eng. and D.Eng. Programmes. An increase in students will only increase the efficiency of these courses.

V) Research Results. Results of research related to the area of building systems have been presented in the last year not only at conferences in Canada and in the USA but also at international congresses in Germany and in Spain.

Results from the research activities carried out by D.Eng. students are circulated in the Engineering Faculty in the form of Internal Research Reports. Two copies of each report are

kept in the Science and Engineering Library as references.

Lab Facilities

A structures-test-frame and a data acquisition system have been added to the lab facilities which were listed in Appendix VII of the D.Eng. Proposal. Optimum utilization of lab facilities, space, and structural models can be achieved by increasing the number of full-time-equivalent students to twenty-two and by organizing the research activities as shown in Appendix I. These activities do not hinder normal use of these facilities by undergraduate students. In fact, a number of these students could be involved as research helpers on the D.Eng. projects. Planned facilities for 1970-71 could provide space for 8 additional full-time-equivalent students to bring the total number to 30.

Available Faculty Capability to Supervise Students

Full utilization of available Faculty capability can be achieved as shown in Appendix II. Each Faculty member should on the average be guiding three D.Eng. students. A D.Eng. student with a Master's degree requires two to three years to complete his program. Normally in his first year, the student devotes most of his time to course work. It is during his second year when he undertakes his research work that he will require the most contact with his supervisor. On his third year, when finishing his work and preparing his thesis, he is expected to be largely independent. Appendix II shows that 15 full-time-equivalent

graduate students and 14 D.Eng. can be supervised by the present Faculty members in Structures.

Financial Support

The financial support is detailed in Appendices I, II and III. Appendix I shows the research grants to members of the Structures group in the past two years. The total support increased from $31,870 in 1968 to $53,500 in 1969. The projected research grants for the next three years is shown in Appendix IV. The amounts of $78,000, $108,000 and $138,000 for 1970-71, and 1972-72, respectively can be achieved with an increase in research input. The proposed distribution of funds in Appendix V shows that by 1972-73 support should be available for 2 Research Associates, 3 Doctoral Fellowships, 12 Doctorate Students, 6 Research Assistants, 4 Faculty Fellowships, $11,000 for undergraduate students help and $26,000 for supplies and travelling.

Conclusion

Both the lab facilities and Faculty capability to supervise D.Eng. students show that a maximum number of 14 can be accommodated. The financial resources show that 12 D.Eng. students and 3 Doctoral Fellowships could be supported by 1972-73. These projected figures of research support are dependent upon the productivity of the Sturctures group which in turn is affected by the number of students allowed to enroll in the D.Eng. Programme.

The programme has acquired a strong impetus through the

immediate interest and financial support of industry.

It is hoped that this impetus be allowed to continue in order to satisfy the requirements of industry, faculty and the need for optimum use of our facilities. We, therefore, recommend that the number of students which shoudl be admitted into the D.Eng. Programme each year should be determined by the availability of: (a) qualified students, (b) financial support, and (c) Faculty capability for supervision. According to our projected development it would seem reasonable to admit thirty full-time-equivalent graduate students by 1972-73, half of these being Doctoral students.

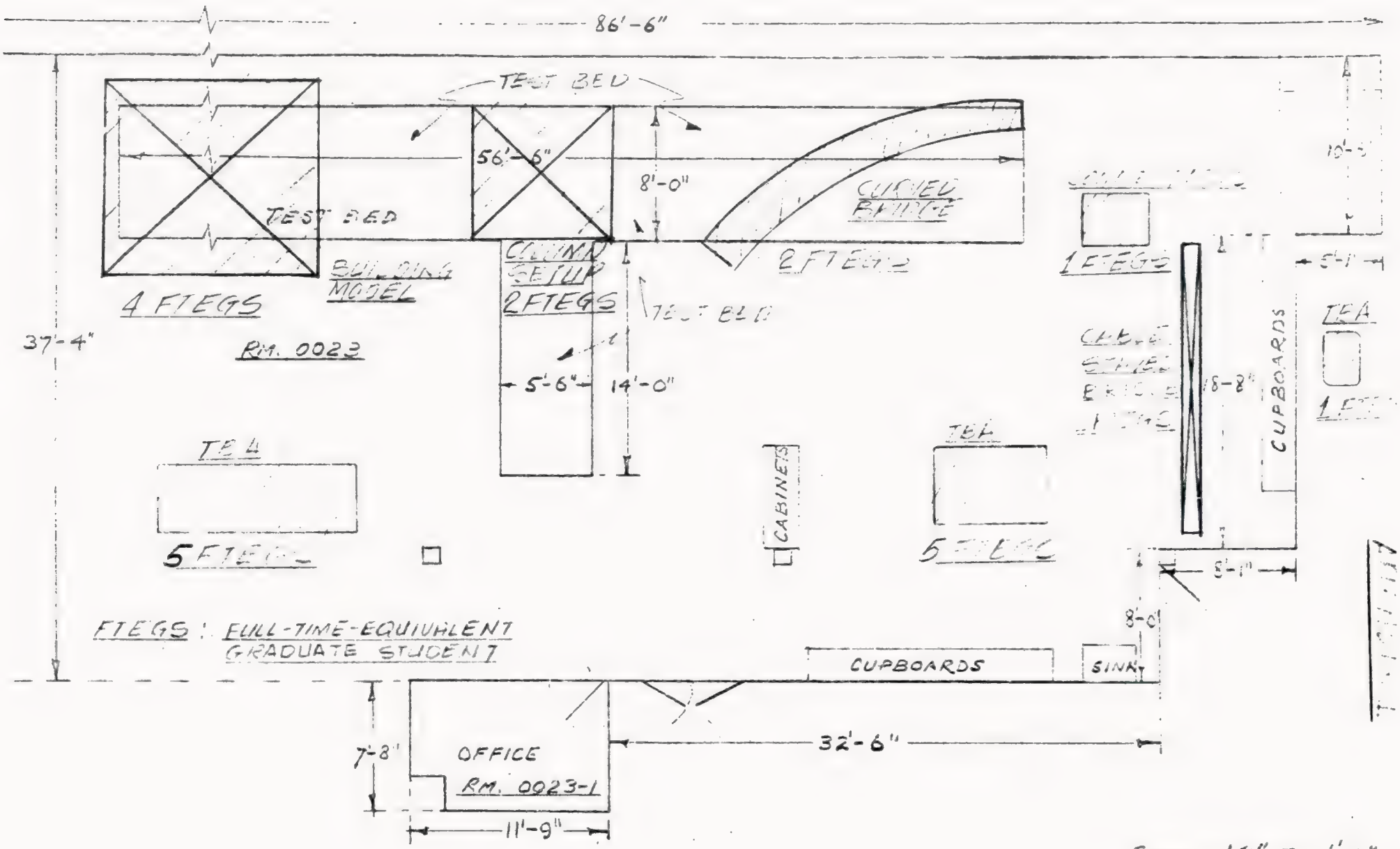
REFERENCES

1. Dietz, G.H. Albert, Future Potential of Building Systems, ASCE Annual Meeting and National Meeting on Sturctural Engineering, Pittsburg, Pa., September 30 - October 4, 1968.

2. Dietz, G.H. Albert, Building Technology: Potential and Problems, paper presented at symposium on Industrialized Building at MIT on August 17 - 29, 1964.

3. Graduate Students at Canadian Universities, Report on the National Research Council of Canada for 1968-69.

STRUCTURES LAB



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ORGANIZATION OF REGION 4 ACTIVITIES

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APPENDIX II

ESTIMATE OF FACULTY RESOURCES AVAILABLE FOR SUPERVISION OF FULL-TIME EQUIVALENT GRADUATE STUDENTS

Faculty Member	M.Eng. Full-Time-Equivalent	D.Eng
* M.S. Troitsky	2	3
* C. Marsh	2	3
*P.P. Fazio	2	3
M.M. Douglass	3	-
P.J. Fang	2	3
F.A. Gerard	2	-
T.S. Sankar	1	1
M.O.M. Osman	1	1

*These Faculty members are guiding D.Eng. students at present.

APPENDIX III

RESEARCH GRANTS TO MEMBERS OF THE STRUCTURES GROUP IN THE PAST TWO YEARS

RESEARCHERS	1968-69 NRC	1968-69 INDUSTRY	1968-69 CASA	1969-70 NRC	1969-70 INDUSTRY	1969-70 CASA
M.S. Troitsky	4,900		1,600	4,850		
C. Marsh	NA			3,000	12,000	
P.P. Fazio	2,960	4,000	2,710	5,850	4,000	1,200
M.M. Douglass	5,000		3,100	5,000		1,000
P.J. Fang	NA			4,000		1,000
F.A. Gerard	NA					
T.S. Sankar	NA			2,000*		
M.O.M. Osman	NA			2,000*		
**B. Lazar	7,200	400		7,200	400	
**A. Salahuddin		(4,000)†			(4,000)†	
**J. Mikler		NA			(5,000)†	
Sub-total:	20,060	4,400	7,410	33,900	16,400	3,200
TOTAL:	$31,870				$53,500	

* Partial support to Structures
*** Fellowship
† Supported through faculty grants.

APPENDIX IV

PRESENT AND PROJECTED RESEARCH GRANTS

SOURCE	PAST	PRESENT	FUTURE		
	1968-69	1969-70	1970-71	1971-72	1972-73
NRC	20,060	33,900	45,000	57,000	70,000
DRB	-	-	2,000	4,000	6,000
CHMC	-	-	-	3,000	5,000
CISC	-	-	2,000	3,000	4,000
CASA	7,410	3,200	2,000	1,000	1,000
INDUSTRY	4,400	16,400	27,000	40,000	52,000
TOTAL:	31,870	53,500	78,000	108,000	138,000

APPENDIX V

PROPOSED DISTRIBUTION OF FUNDS

DISTRIBUTION	1969/70		1970/71		1971/72		1972/73	
	NO.	COST	NO.	COST	NO.	COST	NO.	COST
Research Assoc.	1	-	1	8,000	2	16,000	2	16,000
Doctoral Fellowship	3	16,000	2	9,000	3	15,000	3	15,000
Doct. Students	3	9,000	8	24,000	10	30,000	12	36,000
Research Asst.	1	3,000	3	9,000	5	15,000	6	18,000
Faculty Fellowship	-	-	2	8,000	3	12,000	4	16,000
Asst. from Undergraduate	-	5,000	-	7,000		9,000		11,000
Other		20,500		13,000		11,000		26,000
TOTAL:$		53,500		78,000		108,000		138,000

NOTE: The full-time-equivalent students from the M.Eng. programe are self-supporting.